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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 733161	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. **PCT/AU2004/001611**	International filing date *(day/month/year)* 19 November 2004	Priority date *(day/month/year)* 19 November 2003
International Patent Classification (IPC) or national classification and IPC Int. Cl. ***F16L 9/08*** (2006.01)		
Applicant ROCLA PTY LTD et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of 9 sheets, as follows:
      - [ ] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand 31 August 2005	Date of completion of this report 27 January 2006
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **JASON PREMNATH** Telephone No. (02) 6283 2127

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2004/001611

Box No. I Basis of the report

1. With regard to the **language**, this report is based on:

[X] The international application in the language in which it was filed

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of:

[ ] international search (under Rules 12.3(a) and 23.1 (b))

[ ] publication of the international application (under Rule 12.4(a))

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished

[X] the description:

pages **1, 3 - 13** as originally filed/furnished
pages* **2, 2a, 2b** received by this Authority on **17 January 2006** with the letter of **17 January 2006**
pages* received by this Authority on with the letter of

[X] the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* **14 - 19** received by this Authority on **17 January 2006** with the letter of **17 January 2006**
pages* received by this Authority on with the letter of

[X] the drawings:

pages **1, 2** as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims **1 - 32**	**YES**
	Claims	**NO**
Inventive step (IS)	Claims **1 - 32**	**YES**
	Claims	**NO**
Industrial applicability (IA)	Claims **1 - 32**	**YES**
	Claims	**NO**

2. Citations and explanations (Rule 70.7)

Novelty (N) and Inventive Step (IS)

Claims 1 - 32 relate to a cementitious pipe suitable for underground use or a method of producing such a pipe. These claims are novel when compared with the documents mentioned in the International Search Report.

EP 887486 (D1) is considered to be closest prior art document. This document discloses an amorphous metal fibre-reinforced concrete composition suitable for a variety of concrete components including pipes. Claims of the present application define a behaviour for the pipe based on a stress verses relative displacement curve as per 3-edge bearing method. D1 discloses a stress verses displacement curve for a plate which may not be applicable for a pipe. It is considered that D1 does not teach the invention defined in the claims 1 - 32.

Accordingly claims 1- 32 are novel and considered to involve an inventive step.

of their physical properties with age and they can tend to delaminate under high loads, particularly after long exposure to ground water.

Broad Summary of the Invention

The present invention is directed to providing an alternative form of cementitious pipe of a type suitable for below ground use.

According to the present invention, there is provided a cementitious pipe suitable for below ground use, wherein said pipe has a tubular wall of fibre-reinforced cementitious matrix or material which is produced by dewatering extrusion of a fibre-containing cementitious mix and which is capable of exhibiting pseudo strain hardening (PSH) behaviour, said wall has a wall thickness to diameter ratio within a range, and the cementitious material and the range for said wall thickness to diameter ratio are such that the pipe exhibits characteristic behaviour in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and wherein said behaviour is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slope S_1 of from about 1000 MPa to 1700 MPa and, from a limit of proportionality (LOP) of from about 4MPa to about 12 MPa for the elastic region to a modulus of rupture (MOR) for the pipe of from about 10 MPa to about 20 MPa, a PSH region which, beyond a possible transition region, has a slope S_3 which is less than that of the elastic region and is from a small positive value less than $0.04S_1$ up to about $0.25S_1$; whereby the pipe while subjected to loadings generating stress up to the LOP is able to function as a rigid pipe and, at loadings generating stress levels in excess of the LOP and up to the MOR, the pipe is able to function as a flexible pipe due to the effects of PSH.

The present invention also provides a method of producing cementitious pipe suitable for below ground use, wherein said method includes subjecting a fibre-containing cementitious mix to extrusion dewatering thereby forming a tubular green body, and curing said green body to provide a cured pipe having a tubular wall of fibre-reinforced cementitious matrix or material capable of exhibiting pseudo strain hardening (PSH) behaviour, and wherein the cementitious mix is extruded such that said wall has a wall thickness to diameter ratio within a range, and wherein said forming and the cementitious mix are controlled whereby the range for said wall thickness to diameter ratio is

such that the cured pipe exhibits characteristic behaviour in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and such said behaviour is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slopeS_1 of from about 1000 MPa to about 1700 MPa and, from a limit of proportionality (LOP) of from about 4MPa to about 12 MPa for the elastic region to the modulus of rupture (MOR) for the pipe of from about 10 MPa to about 20 MPa, a PSH region which, beyond a possible transition region, has a slope S_3 which is less than that of the elastic region and is from a small positive value less than $0.04S_1$ up to about $0.25S_1$; whereby the pipe while subjected to loadings generating stress up to the LOP is able to function as a rigid pipe and, at loadings generating stress levels in excess of the LOP and up to the MOR, the pipe is able to function as a flexible pipe due to the effects of PSH.

As indicated herein, the green body produced in making a pipe according to the present invention has sufficient green strength to enable it to be removed from an extruder in which it is produced and then to be handled without distortion. This applies even with the onset of little if any significant hydration in the green body, and despite handling of the green body well prior to attainment of a fully cured pipe. As will be appreciated, sufficient curing is necessary for attainment with the required stress versus relative displacement curve. Unless there is force curing as the green body is produced, curing over a period of up to about 20 days, or more, can be necessary.

A pipe according to the present invention has a relatively low wall thickness to internal diameter ratio. For a given pipe diameter, the wall thickness is a relatively narrow range, with wall thickness range increasing with increase in diameter. Illustrative examples of wall thickness ranges relative to the internal diameters for standard pipe sizes are as follows:

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Pipe Diameter	Wall thickness – General		Wall Thickness – Preferred	
	Minimum	Maximum	Minimum	Maximum
225mm	5mm	9mm	6mm	8mm
375mm	8mm	15mm	9mm	13mm
750mm	16mm	30mm	20mm	26mm
2100mm	45mm	85mm	55mm	75mm

The relatively low wall thickness to diameter ratio for the pipe of the present invention is of importance in the pipe attaining the required stress/relative displacement curve, and resultant distinctive performance characteristics. The low ratio also enables a cost-effective use of the fiber-reinforced cementitious material, and a relatively low weight for the pipe per unit length.

CLAIMS

1. A cementitious pipe suitable for below ground use, wherein said pipe has a tubular wall of fibre-reinforced cementitious matrix or material which is produced by dewatering extrusion of a fibre-containing cementitious mix and which is capable of exhibiting pseudo strain hardening (PSH) behaviour, said wall has a wall thickness to diameter ratio within a range, and the cementitious material and the range for said wall thickness to diameter ratio are such that the pipe exhibits characteristic behaviour in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and wherein said behaviour is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slope S_1 of from about 1000 MPa to 1700 MPa and, from a limit of proportionality (LOP) of from about 4MPa to about 12 MPa for the elastic region to a modulus of rupture (MOR) for the pipe of from about 10 MPa to about 20 MPa, a PSH region which, beyond a possible transition region, has a slope S_3 which is less than that of the elastic region and is from a small positive value less than $0.04S_1$ up to about $0.25S_1$; whereby the pipe while subjected to loadings generating stress up to the LOP is able to function as a rigid pipe and, at loadings generating stress levels in excess of the LOP and up to the MOR, the pipe is able to function as a flexible pipe due to the effects of PSH.

2. The pipe of claim 1, wherein the wall has a relatively low wall thickness to diameter ratio.

3. The pipe of claim 1 or claim 2, wherein for a given wall diameter, the wall thickness is within a relatively narrow range, with the wall thickness range for a pipe having a wall of a given larger diameter being greater than the wall thickness range for a pipe having a wall of a given smaller diameter.

4. The pipe of claim 3, wherein the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

Wall Diameter	Wall Thickness Range
225mm	5 to 9mm
375mm	8 to 15mm
750mm	16 to 30mm
2100mm	45 to 85mm

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5. The pipe of claim 3, wherein the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

Wall Diameter	Wall Thickness Range
225mm	6 to 8mm
375mm	9 to 13mm
750mm	20 to 26mm
2100mm	55 to 75mm

6. The pipe of any one of claims 1 to 5, wherein the stress versus relative displacement curve, when tested by the 3 edge bearing method of Australian Standard AS4139-2003, has a value for the LOP of from about 5 to 10 MPa, for example from 5 to 7 MPa.

7. The pipe of any one of claims 1 to 5, wherein the stress versus relative displacement curve, when tested by the 3 edge bearing method of Australian Standard AS41392003, has a value at the cracking strength of the matrix in initial testing of from about 4 to 12 MPa, such as from 5 to 10 MPa, for example 5 to 7MPa.

8. The pipe of claim 6 or claim 7, wherein said curve, when so tested, has a relative displacement (δ_1) at the limit of elastic deformation of from about 0.3% to about 0.9%, such as from 0.4 to 0.8%, for example 0.6 to 0.8%.

9. The pipe of any one of claims 6 to 8, wherein said curve when so tested, has a first, transition part of the PSH region of the curve which ranges up to a relative displacement (δ_2) of about 1.7%, such as from 1.1 to 1.5%, for example about 1.2%.

10. The pipe of any one of claims 6 to 9, wherein said curve, when so tested, has at least a major part of the PSH region which ranges up to a displacement (δ_3) of about 11%, preferably within the range of from about 2% to about 11%, such as from about 3% to 10%, for example, from about 5% to about 9%.

11. The pipe of any one of claims 6 to 10, wherein said curve, when so tested, has a MOR of from about 10 to 17 MPa, for example from about 10 to 15 MPa, such as about 11 to 15 MPa.

12. The pipe of any one of claims 6 to 11, wherein said curve has a slope (S_1) over the linear portion of the curve, within said first limits, of from 1000 MPa to 1650 MPa, for example about 1330 MPa to 1650 MPa.

13. The pipe of any one of claims 6 to 12, wherein at least a major part of the length of the PSH region of said curve has a positive slope (S_3) which ranges, within said second limits, from about 0.04 S_1 to 0.25 S_1, such as from about 0.05 S_1 to 0.25S_1, and wherein said PSH region fluctuates in amplitude and said slope S_3 is the slope of a smoothed trend line for the PSH region.

14. The pipe of any one of claims 1 to 13, wherein said tubular wall is of substantially circular cross-section and of substantially constant cross-sectional form substantially throughout its length.

15. The pipe of any one of claims 1 to 14, wherein the cementitious matrix is based on Portland cement and includes pozzolanic material such as flyash, silica fume, slag and combinations thereof.

16. The pipe of any one of claims 1 to 14, wherein the cementitious matrix comprises an alkali-active cement based on a pozzolanic material such as flyash, silica fume and combinations thereof.

17. The pipe of claim 15, or claim 16, wherein the cementitious matrix has discontinuous fibres dispersed therethrough, such as metallic, polymeric, ceramic fibers, and combinations thereof, in relatively short fibre length of from 3mm to 24mm in length.

18. The pipe of any one of claims 1 to 17, wherein the cementitious material is an engineered cementitious composite.

19. The pipe of any one of claims 1 to 18, wherein the pipe is produced by dewatering extrusion of a suitable cementitious material having a water content providing a ratio of water to binder (cement plus pozzolanic) of about 0.3 to 0.5, and wherein the ratio is reduced during extrusion to about 0.24 to 0.26.

20. The pipe of any one of claims 1 to 19, wherein the tubular wall of the pipe is of a material which has a value for Young's modulus of from 20 GPa to 40 GPa, such as from 30 GPa to 35 GPa.

21. The pipe of any one of claims 1 to 20, wherein the tubular wall of the pipe is of a material which has a compressive strength of from 40 to 100 MPa, such as from 45 to 75 MPa, for example 50 to 70 MPa.

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22. The pipe of any one of claims 1 to 21, wherein the pipe has a composite failure stress of from 5 to 14 MPa, such as from 6 to 12 MPa, for example 6 to 9 MPa.

23. A method of producing cementitious pipe suitable for below ground use, wherein said method includes subjecting a fibre-containing cementitious mix to dewatering extrusion thereby forming a tubular green body, and curing said green body to provide a cured pipe having a tubular wall of fibre-reinforced cementitious matrix or material capable of exhibiting pseudo strain hardening (PSH) behaviour, and wherein the cementitious mix is extruded such that said wall has a wall thickness to diameter ratio within a range, and wherein said forming and the cementitious mix are controlled whereby the range for said wall thickness to diameter ratio is such that the cured pipe exhibits characteristic behaviour in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and such said behaviour is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slopeS_1 of from about 1000 MPa to about 1700 MPa and, from a limit of proportionality (LOP) of from about 4MPa to about 12 MPa for the elastic region to the modulus of rupture (MOR) for the pipe of from about 10 MPa to about 20 MPa, a PSH region which, beyond a possible transition region, has a slope S_3 which is less than that of the elastic region and is from a small positive value less than $0.04S_1$ up to about $0.25S_1$; whereby the pipe while subjected to loadings generating stress up to the LOP is able to function as a rigid pipe and, at loadings generating stress levels in excess of the LOP and up to the MOR, the pipe is able to function as a flexible pipe due to the effects of PSH.

24. The method of claim 23, wherein the forming is controlled such that the wall has a relatively low wall thickness to diameter ratio.

25. The method of claim 23 or claim 24, wherein forming is controlled such that the for a given wall diameter, the wall thickness is within a relatively narrow range, with the wall thickness range for a pipe having a wall of a given larger diameter being greater than the wall thickness range for a pipe having a wall of a given smaller diameter.

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26. The method of claim 25, wherein forming is controlled such that the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

Wall Diameter	Wall Thickness Range
225mm	5 to 9mm
375mm	8 to 15mm
750mm	16 to 30mm
2100mm	45 to 85mm

27. The method of claim 25, wherein forming is controlled such that the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

Wall Diameter	Wall Thickness Range
225mm	6 to 8mm
375mm	9 to 13mm
750mm	20 to 26mm
2100mm	55 to 75mm

28. The method of any one of claims 23 to 27, wherein said forming is controlled such that the tubular wall is of substantially circular cross-section and of substantially constant cross-sectional form substantially throughout its length.

29. The method of any one of claims 23 to 28, wherein the cementitious matrix is selected from a matrix based on:

(a) Portland cement and includes pozzolanic material such as flyash, silica fume, slag and combinations thereof; or

(b) an alkali-active cement based on a pozzolanic material such as flyash, silica fume and combinations thereof.

30. The method of claim 29, wherein the cementitious matrix has discontinuous fibres dispersed therethrough, such as metallic, polymeric, ceramic fibers, and combinations thereof, in relatively short fibre length of from 3mm to 24mm in length.

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31. The method of any one of claims 23 to 30, wherein the cementitious material is an engineered cementitious composite.

32. The method of any one of claims 23 to 31, wherein the pipe is produced by dewatering extrusion of a suitable cementitious mix having a water content providing a ratio of water to binder (cement plus pozzolanic) of about 0.3 to 0.5, and wherein the ratio is reduced by said dewatering extrusion to about 0.24 to 0.26.